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BRINKS HOFER GILSON &LIONE

CERTIFICATE OF MAILING UNDER 37 C.F.R. §1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage, in an envelope addressed to: Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450, on the below date:

Date: April 5, 2005 Name: G. Peter Nichols Signature: [signature]

OIPE APR 0 8 2005 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of: Craig Van Buuren

Appln. No.: 10/796,557

Filed: March 9, 2004

For: Method of and Apparatus for Simulating a Biological Heap Leaching Process

Attorney Docket No: 10908/9

Examiner: N/A

Art Unit: 1754

Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Sir:

Attached is/are:

☒ Submission of Certified Copy of Priority Document; South African Provisional Patent Application No. 2003/9936, filed December 23, 2003

☒ Return Receipt Postcard

Fee calculation:

☐ No additional fee is required.

☐ Small Entity.

☐ An extension fee in an amount of $_____ for a _____-month extension of time under 37 C.F.R. § 1.136(a).

☐ A petition or processing fee in an amount of $_____ under 37 C.F.R. § 1.17(_____).

☐ An additional filing fee has been calculated as shown below:

						Small Entity			Not a Small Entity	
	Claims Remaining After Amendment		Highest No. Previously Paid For	Present Extra		Rate	Add'l Fee	or	Rate	Add'l Fee
Total		Minus				x $25=			x $50=	
Indep.		Minus				x 100=			x $200=	
First Presentation of Multiple Dep. Claim						+$180=			+ $360=	
						Total	$		Total	$

Fee payment:

☐ A check in the amount of $_____ is enclosed.

☐ Please charge Deposit Account No. 23-1925 in the amount of $. A copy of this Transmittal is enclosed for this purpose.

☐ Payment by credit card in the amount of $_____ (Form PTO-2038 is attached).

☒ The Director is hereby authorized to charge payment of any additional filing fees required under 37 CFR § 1.16 and any patent application processing fees under 37 CFR § 1.17 associated with this paper (including any extension fee required to ensure that this paper is timely filed), or to credit any overpayment, to Deposit Account No. 23-1925.

Respectfully submitted,

[signature]

April 5, 2005
Date

G. Peter Nichols (Reg. No. 34,401)

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OIPE JC105 APR 08 2005 PATENT & TRADEMARK OFFICE

Date of Deposit: April 5, 2005

G. Peter Nichols, Reg. No. 34,401
Name of Applicant, Assignee or Registered Representative

Signature

Our File No. 10908/9

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)
Craig Van Buuren	)
Serial No. 10/796,557	) Examiner: unknown
Filing Date: March 9, 2004	)
For METHOD OF AND APPARATUS FOR SIMULATING A BIOLOGICAL HEAP LEACHING PROCESS	) Group Art Unit: 1754

SUBMISSION OF CERTIFIED COPY OF PRIORITY DOCUMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Transmitted herewith is a certified copy of the following priority document for the above-named U.S. application:

1. South African Provisional Patent Application No. 2003/9936, filed December 23, 2003

Respectfully submitted,

G. Peter Nichols
Registration No. 34,401
Attorney for Applicant

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Sertifikaat

REPUBLIC OF SOUTH AFRICA

PATENT KANTOOR
DEPARTEMENT VAN HANDEL
EN NYWERHEID

Certificate

REPUBLIEK VAN SUID-AFRIKA

PATENT OFFICE
DEPARTMENT OF TRADE AND
INDUSTRY

Hiermee word gesertifiseer dat
This is to certify that

the documents annexed hereto are true copies of:

Application forms P.1, P.2, provisional specification and drawing of South African Patent Application No. 2003/9936 as originally filed in the Republic of South Africa on 23 December 2003 in the name of BHP BILLITON SA LIMITED for an invention entitled:

" METHOD OF AND APPARATUS FOR SIMULATING A BIOLOGICAL HEAP LEACHING PROCESS ".

Geteken te **PRETORIA** in die Republiek van Suid-Afrika, hierdie 23th dag van **February 2004**
Signed at in the Republic of South Africa, this day of

....
Registrar of Patents

CERTIFIED COPY OF
PRIORITY DOCUMENT

FORM P2

MRF Ref:P.19912

REPUBLIC OF SOUTH AFRICA — PATENTS ACT, 1978

REGISTRAR OF PATENTS

Official Application No.		Lodging date: Provisional		Acceptance date:	
21	01 2003/9936	22	23 December 2003	47	
International classification		Lodging date: Complete		Granted date:	
51		23			

Full name(s) of applicant(s)/Patentee(s)	
71	BHP BILLITON SA LIMITED

Applicant(s) substituted:		Date Registered:
71		

Assignee(s):		Date Registered:
71		

Full name(s) of inventor(s)	
72	VAN BUUREN, Craig

Priority claimed	Country		Number		Date	
Note:	33	NONE	31	NONE	32	NONE
Use International	33		31		32	
Abbreviation for Country	33		31		32	

Title of Invention:	
54	METHOD OF AND APPARATUS FOR SIMULATING A BIOLOGICAL HEAP LEACHING PROCESS

Address of applicant(s)/patentee(s)
200 Hans Strijdom Drive, Randburg, 2125

Address for Service:	
74	**McCALLUM, RADEMEYER & FREIMOND, Maclyn House, 7 June Avenue, Bordeaux, Randburg • P.O. Box 1130, Randburg 2125**

Patent of Addition to Patent No.:		Date of any change:	
61			
Fresh Application based on:		Date of any change:	

McCALLUM, RADEMEYER & FREIMOND
Ref: P.19912

REVENUE INKOMSTE 23.12.03

REPUBLIEK VAN SUID-AFRIKA
REVENUE R 0060.00 INKOMSTE
FORM P1
FTR 074
REPUBLIC OF SOUTH-AFRICA

REPUBLIC OF SOUTH AFRICA
PATENTS ACT,1978

APPLICATION FOR A PATENT AND ACKNOWLEDGEMENT OF RECEIPT

(Section 30(1) – Regulation 22)

The grant of a patent is hereby requested by the undermentioned applicant on the basis of the present application filed in duplicate

Revenue Stamps or Revenue Franking Machine Impression

OFFICIAL DATE STAMP

OFFICIAL APPLICATION NO.

21	01	2003/9936

FULL NAME(S) OF APPLICANT(S)

71	BHP BILLITON SA LIMITED

ADDRESS(ES) OF APPLICANT(S)

	200 Hans Strijdom Drive, Randburg, 2125

TITLE OF INVENTION

54	METHOD OF AND APPARATUS FOR SIMULATING A BIOLOGICAL HEAP LEACHING PROCESS

Priority is claimed as set out on the accompanying Form P2.

The earliest priority claimed is: NONE

This application is a patent of addition to Patent Application No.	21	01	
This application is a fresh application in terms of section 37 and based on Application No.	21	01	

THIS APPLICATION IS ACCOMPANIED BY:

- ☒ 1 A single copy of a provisional specification of ...13... pages
- ☐ 2 Two copies of a complete specification of ...... pages
- ☒ 3 ...1 ... Sheet of Informal Drawings
- ☐ 4 .... Sheets of Formal Drawings
- ☐ 5 Publication particulars and abstract (Form P8 in duplicate)
- ☐ 6 A copy of Figure .... of drawings (if any) for the abstract
- ☐ 7 Assignment of Invention
- ☐ 8 Certified priority document(s) Number(s)
- ☐ 9 Translation of priority document(s)
- ☐ 10 An assignment of priority rights
- ☐ 11 A copy of the Form P2 and the specification of SA Patent Application | 21 | 01 |
- ☐ 12 A declaration and power of attorney on Form P3
- ☐ 13 Request for ante-dating on Form P4
- ☐ 14 Request for classification on Form P9
- ☒ 15 Form P2 in duplicate

74	ADDRESS FOR SERVICE: McCALLUM, RADEMEYER & FREIMOND, Madyn House, June Avenue, Bordeaux P.O. Box 1130, Randburg, 2125

Dated 23 December 2003

....
McCALLUM, RADEMEYER & FREIMOND
PATENT AGENTS FOR APPLICANT(S)

Received – Official Date Stamp

2003 -12- 23

REGISTRAR OF PATENTS

REGISTRATEUR VAN PATENTE, MODELLE, HANDELSMERKE EN OUTEURSREG

McCALLUM, RADEMEYER & FREIMOND
Ref: P.19912

FORM P6

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

PROVISIONAL SPECIFICATION

(Section 30(1) – Regulation 27)

OFFICIAL APPLICATION NO

21	01	2003/9936

LODGING DATE

22	23 December 2003

FULL NAME(S) OF APPLICANT(S)

71	BHP BILLITON SA LIMITED

FULL NAME(S) OF INVENTOR(S)

72	VAN BUUREN, Craig

TITLE OF INVENTION

54	METHOD OF AND APPARATUS FOR SIMULATING A BIOLOGICAL HEAP LEACHING PROCESS

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to the microbiological leaching of ore in a heap and is concerned, more particularly, with the simulation of certain aspects thereof.

[0002] In a microbiological heap leaching application mined ore is crushed and agglomerated with acid and nutrients. Oxygen and carbon dioxide are supplied to the ore to provide an environment for organism growth and to promote the oxidising conditions required for mineral degradation.

[0003] Normally the acidic solution is applied to the top of the ore heap and is allowed to percolate downwardly while the oxygen and carbon dioxide are supplied in the form of air introduced to the bottom of the heap. The air flowing upwardly and the acidic solution flowing downwardly, through the heap, are counter current transport media which interact at different points of the heap allowing oxygen transfer, species migration and a heat exchange mechanism within the heap.

[0004] It is known that a heap leaching process is temperature-dependent with determining factors including the ore type and the microorganisms which are used for the leaching. For example, the acidic solubilisation of copper from copper oxide ores, chalcocitic ores and other secondary copper sulphide bearing ores, at low temperatures, may result in an acceptable recovery of the metal. On the other hand minerals such as enargite, carrollite and

chalcopyrite are slow leaching at low temperatures, below 30°C, and leaching at these temperature results in poor metal extraction which, in most instances, is uneconomical.

[0005] The enhanced oxidation of the sulphide components of minerals of the aforementioned type, by microbiological action, is an exothermic reaction which releases substantial amounts of energy, a process which must be correctly managed to obtain effective metal recovery.

[0006] It is extremely difficult and expensive to monitor conditions inside a commercially operated heap due, primarily, to the size of a typical heap and the amount of material it contains.

SUMMARY OF INVENTION

[0007] The invention is concerned with simulating certain aspects of a microbiological heap leaching process.

[0008] The invention provides, in the first instance, apparatus for simulating a process in which ore, in a heap, is microbiologically leached, the apparatus including a housing in which material, representative of the ore, is microbiologically leached, a plurality of sensors for measuring the temperature of the material at each of a plurality of locations in the housing, and a control system which, in response to the temperature measurements from the sensors, controls heat loss from the material in the housing to atmosphere.

[0009] The housing may be of any appropriate shape and size but preferably is a tubular column. The column may be oriented so that it extends with its longitudinal axis vertical and with an upper and lower end.

[0010] The column may be made in any appropriate way and preferably is made from a plurality of modular components which are secured together. This enables the effective height of the column to be adjusted so that account can be taken of heaps of different depths.

[0011] The housing may include insulation for restricting heat loss from the housing.

[0012] The apparatus may include at least one heat source which is controlled by the control system and which raises the temperature of the housing, at least at one location, in a manner which depends on the temperature of the ore inside the housing.

[0013] The heat source may be of any appropriate kind but preferably use is made of a plurality of electrical elements each of which is separately controllable by the control system.

[0014] In an electrical sense the column may be divided into a plurality of segments which extend adjacent each other in a vertical direction and the temperature of each segment may be controllable, to a substantial extent independently of the temperatures in adjacent segments.

[0015] The control system is preferably operated to minimise heat loss from the material in the housing to atmosphere.

[0016] The apparatus may include a system for supplying an acidic liquid medium, on a controlled basis, to the upper end of the housing to simulate the act of irrigating an upper surface of a heap which is leached on a commercial basis.

[0017] The apparatus may include a system for supplying gas on a controlled basis to the lower end of the column. This is done to simulate the supply of oxygen and carbon dioxide to a heap which is operated on a commercial basis.

[0018] The invention also extends to a method of simulating a process in which ore, in a heap, is microbiologically leached, the method including the steps of microbiologically leaching material, representative of the ore, in a confined volume, monitoring the temperature of the material, inside the volume, at each of a plurality of locations and, in response to the monitored temperatures, using a control system to control the heat loss from the confined volume.

[0019] Preferably the control system is operated to reduce heat loss from the confined volume effectively to zero.

[0020] The control system may be used to control the operation of a plurality of independently operable heat sources which are positioned at

predetermined locations relatively to the confined volume. This approach makes it possible to establish a controlled temperature gradient inside the material.

[0021] The method may include the step of varying the composition and flow rate of the acidic liquid medium and of the oxygen and carbon dioxide gases, supplied to the ore, thereby to manipulate the position of a temperature zone in the ore, and to modify the temperature of a given zone in the ore.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a cross sectional view, from one side, of apparatus according to the invention; and

Figure 2 is a cross sectional view of the apparatus in Figure 1 taken on a line 2 – 2.

DESCRIPTION OF PREFERRED EMBODIMENT

[0023] The accompanying drawings illustrate apparatus 10 according to the invention which includes an elongate tubular column 12 which, in use, is oriented so that its longitudinal axis 14 extends vertically, and which has an upper end 16 and a lower end 20.

[0024] In this case the column has two tubular segments 22A and 22B respectively which are stacked one on the other and which are secured together using appropriate fasteners. This modular approach simplifies the manufacture of the column and allows the number of segments to be varied, according to requirement, to approximate heaps of different heights.

[0025] Figure 2 is a cross sectional view of a typical segment 22. The segment includes a stainless steel tube 26 of an appropriate diameter eg. between 800mm and 1200mm which, on an inner surface, has a rubber liner 28 and, on an outer surface, insulating layers 30 to 38 of insulating material, glass fibre and aluminium chosen, according to requirement, to provide an effective and strong insulating cover for the tube 26.

[0026] Each segment has a plurality of supports 40 which extend from an inner surface of the tube 26 into the interior of the tube. The segments are spaced from each other, in a vertical sense, at regular intervals according to predetermined criteria. Each support has a respective sensor 42 fixed to it at its innermost end. The temperature sensors are independently connected to a control system 48 although only some of the connections are shown.

[0027] A plurality of independently controllable heating elements 50 are embedded in the insulating material surrounding the tube 26. Each element is independently connected to the control system 48, although only some of the connections are shown. The control system, in response to temperature measurements from the sensors 42, controls the supply of electrical power from a power source 54 to each element 50.

[0028] The upper end 16 of the column has a cover 60 and a tube 62 extends downwardly from the underside of the cover. A pipe 64, which leads to the tube, is connected to a liquid medium supply source 66 which is also under the control of the system 48. A gas exhaust vent 68 allows excess gas in the column to escape to atmosphere. The exhaust gas can if required be subjected to analysis, using suitable instruments (not shown), to obtain measures of its composition and of its temperature.

[0029] The lower end 20 of the column has a conical cover 70 which acts as a funnel for liquid which drains downwardly from the column, through ore material 72 in the column, and which includes an outlet 74 which can be directed to a facility (not shown) for analysis and processing of the collected liquid, when required. At least one pipe 76 extends into a volume inside the column, immediately above the cover 70, from a gas supply source 80. The supply of gas from the source 80 to the column is controlled by the system 48.

[0030] The column, in use, is filed with material 72 which is representative of ore which is to be leached in a commercial heap leaching operation. The liquid source 66 contains an acid solution, eg. of sulphuric acid, at a pH which, again, is representative of the conditions which prevail in an industrial scale heap leach operation. A mixed microbiological culture of inoculum, also determined by prevailing conditions in a commercial operation, is added to the liquid.

[0031] The gas source 80, which typically is air, is used to introduce oxygen and carbon dioxide into the material 72. It is possible though to use separate

oxygen and carbon dioxide sources in order to vary the oxygen and carbon dioxide proportions from the ratios which prevail in air.

[0032] As has been indicated in the preamble to this specification high temperature (ie. high energy) zones are generated in an industrially operated heap which is microbiologically leached. The apparatus 10 is intended to simulate a notional pillar of ore in a heap, detect the high temperatures zones in the pillar, and provide a mechanism whereby the positions of the zones can be manipulated so that the energy which is generated by the exothermic sulphide oxidation reactions can be managed to establish effective leaching conditions.

[0033] The enhanced oxidation of sulphide sulphur by microbiological action is an exothermic reaction which releases heat energy of the order of 25000kJ/kg of sulphide sulphur oxidised. Although the quantity of heat which is released in a commercial heap is substantial the conditions which prevail in a notional vertical pillar taken through the heap are largely independent of the conditions prevailing elsewhere in the heap primarily due to the insulating effect of the substantial amount of ore which surrounds the pillar. The invention is concerned with simulating the operation of a pillar of this type.

[0034] The microbiological leaching reaction is represented by the following overall chemical and enzymatic equations:

$$FeS_2(s) + 14\,Fe^{3+}(aq) + 8H_20 = 15Fe^{2+}(aq) + 2SO_4^{2-}(aq) + 16H^+$$

(exothermic)

$$\text{Organisms} + 4Fe^{2+}(aq) + O_2(g) + 4H^+ = 4Fe^{3+}(aq) + 2H_20$$

[0035] Each type of microorganism is suited for a specific temperature range and the environmental temperature dictates the type of microorganism active at any time. The microorganisms are selected based on the activity levels in defined temperature ranges. In order to work in the range of 15°C to 45°C the organisms can be selected from the following genus groups: *Acidithiobacillus* (formerly *Thiobacillus*); *Acidimicrobium; Sulfobacillus; Ferroplasma (Ferriplasma); and Alicyclobacillus.*

[0036] For efficient micro-organism operation at a higher temperature range eg. from 45°C to 55°C, suitable moderate thermophile micro-organisms can be selected from the following species: *Acidithiobacillus caldus* (formerly *Thiobacillus caldus*); *Acidimicrobium ferrooxidans; Sulfobacillus acidophilus; Sulfobacillus disulfidooxidans; Sulfobacillus thermosulfidooxidans; Ferroplasma acidarmanus; Thermoplasma acidophylum*; and *Alicyclobacillus acidocaldrius.*

[0037] If higher temperature operation is required, say from 55°C to 85°C, suitable thermophilic micro-organisms are used such as *Sulfolobus metallicus; Sulfolobus acidocaldarius; Sulfolobus thermosulfidooxidans; Acidianus infernus; Metallosphaera sedula; Ferroplasma acidarmanus; Thermoplasma acidophilum; Thermoplasma volcanium;* and *Picrophilus oshimae, Acidianus brierleyi.*

[0038] In use of the apparatus 10 a microbiological leaching process is initiated the material 72 by irrigating the material from the source 66 and by supplying oxygen and carbon dioxide to the column from the source 80. The oxidation process gives rise to zones of different temperatures inside the material with the temperature of each zone being related to the leaching activity in the zone.

[0039] The temperature sensors 42 are used to measure the respective localised temperatures in the zones. Each temperature measurement is applied to the control system 48 which, in turn, controls the supply of electrical energy from the supply 54 to the various elements 50 to force the temperature gradient inside the column, in a transverse direction, at each of the segments which are being separately controlled, effectively to zero. This stops heat transfer out of the column to atmosphere.

[0040] The transfer of heat through an ore body, between two surfaces, is expressed, using Fourier's Law of heat transfer, by the following equation:

$$Q = k\,A\ (T1 - T2) / (X1 - X2)$$

where:

k is the thermal conductivity of the material (W/m/°C);

A is the surface area of heat transfer (m^2) ;

T is the temperature of a respective surface (°C);

X is the distance between the surfaces (m); and

Q is the heat transfer between the surfaces (W).

[0041] From an examination of this equation it is evident that Q tends to zero for X1 >> X2. This is the case for a pillar of rock in a commercial heap which is a substantial distance from a boundary of the heap. In other words the heat loss from a notional pillar inside the heap is effectively zero.

[0042] It is also to be noted that Q tends to zero if T1 = T2. This property is used in the apparatus of the invention for, in any segment of the column 12, by matching the external temperature to the temperature in the corresponding portion of material inside the segment, the transfer of heat to atmosphere can be effectively eliminated, a feature which means that the leaching activity of the material inside the column essentially replicates leaching activity of a notional pillar inside a commercial heap.

[0043] By varying the compositions and the flow rates of the liquid and gas supplied to the material 72 from the sources 66 and 80 respectively it is possible to influence the leaching activity inside the column and thereby simulate leaching inside a commercially operated heap.

[0044] The apparatus of the invention can thus be used to simulate the generation of heat within a heap in which a microbiological oxidation process takes place. A temperature profile can be established in the column which accurately represents the position in a heap. The effect of varying gas and liquid flow rates to a heap on the temperature profile can be assessed and, conversely, the temperature profile can be manipulated by changing the compositions and flow rates of the gas and liquid supplied to the heap.

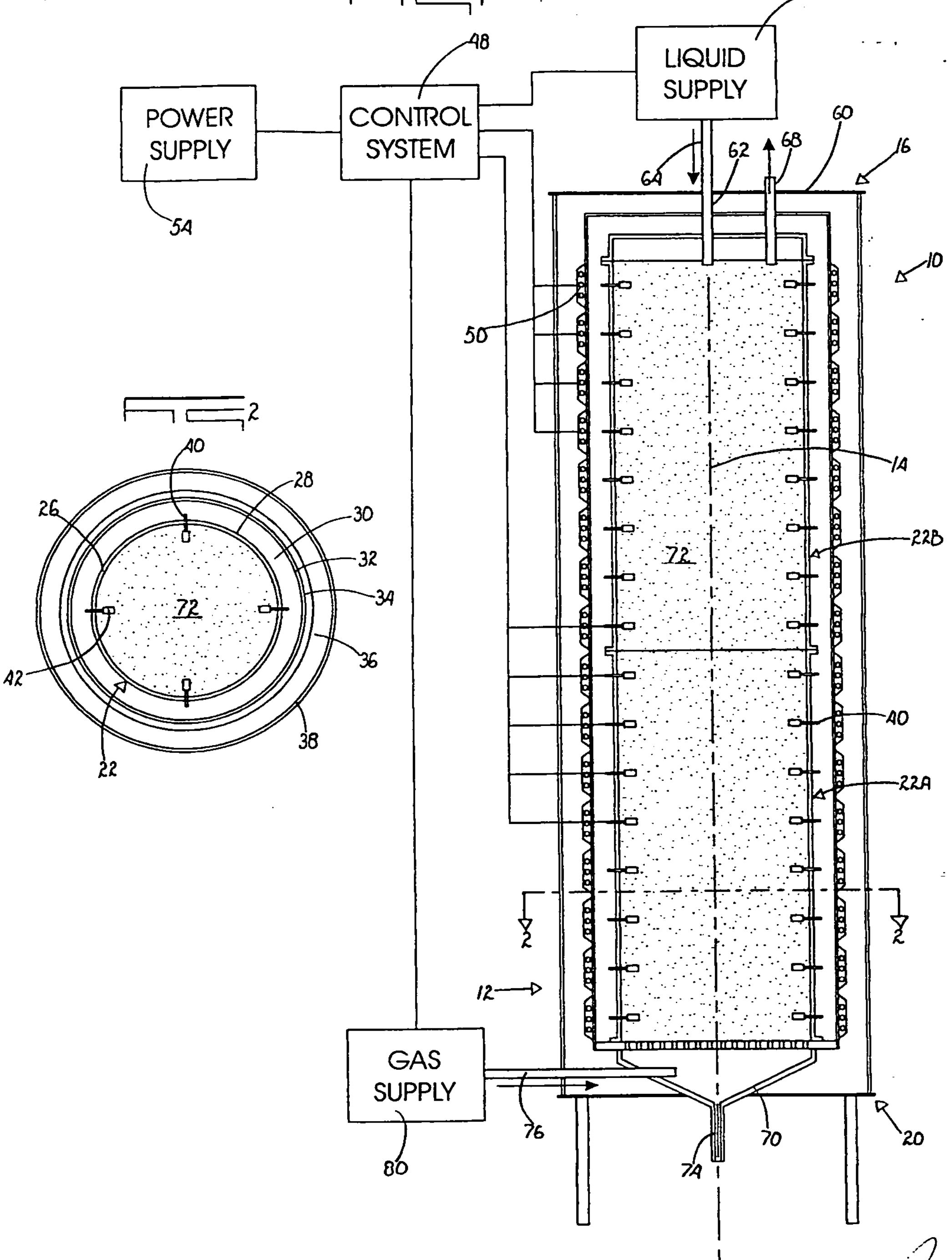
Dated this 23rd day of December 2003.

McCALLUM, RADEMEYER & FREIMOND
Patent Agents for the Applicant

2003/9936

FIG 1

FIG 2



McCALLUM, RADEMEYER & FREIMOND
PATENT AGENTS
FOR THE APPLICANT/s